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Monazite stability as a function of the silicate mineral assemblage in the presence of fluid

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Monazite chemistry and stability are a function of pressure, temperature, and whole rock and fluid composition. One of the current frontiers of monazite petrology is to build monazite and other trace phases into reconstructions of pressure-temperature-time-deformation (P-T-t-d) paths. Thus, it is necessary to understand the behavior of monazite during changing P-T conditions and fluid interactions.

The Carpathian basins were supplied with clastic material derived from several source areas, including external northern sources related to the Brunovistulicum and/or Malopolska Massifs, and internal sources, so-called "cordilleras" (i.e. the Silesian Ridge, and the Southern Magura Ridge). The internal source areas were completely eroded in Tertiary times, and studying the clastic material present in the Carpathian flysch rocks is the only way to improve knowledge concerning evolution of these "cordilleras". This study concerns the processes that affected pebbles of the metamorphosed Cadomian granites from the 60 Ma Silesian Unit flysch rocks (Gródek near the Jezioro Rożnowskie Lake, S Poland). Reactions involving rare earth and heavy minerals are used to reconstruct components of the Pre-Triassic petrogenesis and metamorphism of the former Silesian Ridge.

The major silicate assemblage of metagranitic pebbles from the Silesian Unit is coarse grained, has a foliation defined by mica and by quartz and/or feldspar aggregates, and contains augens of potassic feldspar and plagioclase. The primary accessory phase assemblage consists of zircon + monazite $\pm$ apatite $\pm$ epidote $\pm$ ilmenite $\pm$ rutile. The following reactions, involving plagioclase $\pm$ muscovite or epidote, have been documented:

(i) Mnz_1 + Pl + F^- + H_2O = F-Ap + ThO_2 + Mnz_2 + clay minerals + fluid

(ii) Mnz_1 + Ms + Pl + F^- + H_2O = F-Ap + ThO_2 + Mnz_2 + clay minerals + fluid

(iii) Mnz_1 + Epi + CO_2 + F^- + H_2O = Aln + F-Ap + ThO_2 + bastnasite-synchysite phase + fluid

Secondary apatite consists of polygonal aggregates with minute thorianite inclusions in the cores. Coronas of secondary monazite usually occur around the secondary apatite, and grew as veins or unoriented needle-like aggregates suggesting post-kinematic growth. Secondary monazite is not found in association with allanite. Secondary monazite in all reactions is enriched in HREE, depleted in LREE compared to the primary monazite and also displays Eu enrichment (0.25-0.41wt% Eu_2O_3), which is assumed to be a consequence of plagioclase breakdown. Reactions producing clays, F-apatite, and a bastnasite-synchysite phase, suggest that fluid played a role in the reactions, and that it had significant F and CO_2 activity.

Previous K-Ar and Th-U-Pb studies on similar pebbles constrain metamorphism in the Silesian Ridge to a single Variscan event. Because biotite recrystallizes rapidly in the presence of fluorine, the Variscan age suggests that there is no need to invoke metamorphism during Mesozoic uplift and exhumation. From the textural setting of secondary monazite, we conclude that the retrograde path of Variscan metamorphism resulted in various monazite alteration reactions that were dependent on the effective local chemical system and silicate mineral assemblage.

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